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COURSES IN SPECIAL METHODS OF TEACHING FOR HIGH SCHOOLS, WITH REFERENCE TO MATHEMATICS

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We no longer believe that mere knowledge of subject-matter is the only prerequisite for a teacher of any subject. At the same time we have no desire to minimize the importance of adequate instruction in a range of subject-matter broad and inclusive enough to meet the needs of the prospective teacher. Certainly a wise study of the problems in teaching any subject should be based upon a solid foundation of knowledge in that subject. What we want to do, if possible, is to secure the proper relation between the two points of "method" and "matter" so that one may not be neglected for the other. It is not our purpose in this paper, however, to discuss the subject-matter that should form a proper basis for the prospective teacher, but rather to discuss special methods of handling the subject-matter which our prospective teacher has in his possession when he enters the special-methods course, together with a treatment of whatever subject-matter it may seem necessary to give during the period of instruction. In making a study of the situation the writer has attempted to survey somewhat the history and development of the training of secondary

¹ Paper read before College Teachers of Education at the Minnesota Educational Association at Minneapolis, October 29, 1915.

teachers, especially teachers of secondary mathematics, in Europe and in the United States, with some suggestions in the light of this study as to what may be done with profit in a special-methods course in mathematics.

Twenty years ago little attention was paid to the needs of prospective teachers of secondary subjects, especially to prospective teachers of secondary mathematics. Evidently it never occurred to many college teachers that large numbers of their students were to be the teachers of the next generation and that, as such, they should go out well prepared to give adequate instruction. According to the report of the American Commissioners of the International Commission on the Teaching of Mathematics, "no separate institutions for the training of secondary teachers existed." It seems almost incredible that such an important profession as that of teaching should not have received more consideration. Some of us believe that it is not yet receiving all of the attention that it deserves. For some years past, however, methods courses of one type or another have been offered in many of our leading normal schools and colleges. And the organization of colleges of education throughout the land which are offering special-methods courses in the different subjects is evidence enough that school people generally are beginning to recognize the need for a more technical study of the art of teaching.

The fact remains that a large majority of teachers in this country have had no such preparation in special methods and their only asset is a knowledge of the subject-matter which they are to teach. In many cases even the latter is very meager and inadequate. The report of the American Commissioners of the International Commission on the Teaching of Mathematics says:

The average newly appointed teacher of mathematics is a college graduate who has had only about one year's work (from 90 to 180 class hours) of mathematics beyond the work of the school in which he teaches. The average preparation includes no strictly professional training, no course in the teaching of mathematics to initiate the candidate into the teacher's mode of viewing the events of the classroom. Consequently he enters upon his work with but little mathematical knowledge in advance of his pupils, and with no training at all in the technique of the work he is about to undertake. He is essentially a former pupil, somewhat matured by the general experience of his college

studies and life, come back to teach his quondam fellows. If successful in his work, he develops into a good teacher, at the expense of many mistakes, more or less numerous and serious, according to his measure of native aptitude for the work of a teacher.

On all sides we hear the cry for supervision of teaching. A kind of teaching that results from the sort of preparation described above often amounts to mere telling. It is a shame that such a teacher, especially the new and inexperienced, should be left alone to worry with the thousand problems with which he must surely grapple and often with little success. In spite of all that has been done to improve technique in teaching, there are still many schools which, if they are not entirely ignoring the need for special-methods courses, are surely "marking time" so far as progress is concerned.

But we are in the midst of a great sea of "pedagogical unrest," and we must face the situation with courage and with some degree of security of our moorings if we are to add anything constructive in the way of progressive action. Among the schools which have been giving special-methods courses, remarkable progress has been made in general pedagogical considerations and this has led to a renewed study of the needs of special subjects as modifications of the general situation.

European countries as well as our own have begun to realize the need of a more centralized system for the training of secondary teachers, and in some of these countries, especially in Germany, the need for special training is not so great as it is in many parts of our own country. "The Preparation of Mathematics Teachers" was to have been the main topic of discussion of the International Commission on the Teaching of Mathematics at Munich, Germany, in August, 1915.

This universal "unrest" and desire for improvement in the technique of teaching has led to a more serious study of the situation than formerly and the result has been that many radical changes and reforms, both in the subject-matter and in the teaching of secondary subjects, have been suggested. Until recently most of these proposed changes have been offered with reference to subjects such as the languages and the sciences, but in some cases there have been very marked changes proposed for the

mathematics courses. Commissioner Snedden¹ of Massachusetts and Superintendent Morrison² of New Hampshire are ardent advocates of reform both in the subject-matter and in the teaching of secondary mathematics. A dean³ of one of our best-known colleges of education has recently said, "The social value of geometry has been relatively unchanged in two thousand years," and he adds, "Though geometry may have been the best mathematics available for youth in past centuries, it does not follow that it continues to be the best subject-matter available at the present time." While we may not agree with all of the opinions of different advocates of reform, we must admit that there is some room for improvement both in subject-matter and in methods of teaching.

As a result of all this agitation, teachers of mathematics have begun to ask themselves whether they are really offering the best courses in the most efficient manner. In particular, the people interested in education are beginning to get together and are trying to formulate plans and to organize special-methods courses that will most nearly meet the reasonable demands of the time for progressive action and which will at the same time function the best in the future classroom instruction of the prospective teacher.

The writer of this paper has had the privilege of being in such a conference of teachers and has heard the frank admission from more than one well-known teacher of methods that he realized that his course was not what it should be, that a great deal of his material was "filler," and that something definite should be done to improve the courses in special methods.

The testimony of practice teachers with whom the writer has had some experience has been that they gained a great deal from the methods courses in the way of historical material and knowledge of subject-matter, but since they began to teach they realized that they had received little information about the technique of teaching. It is well known that much of this technical information cannot be given as some of the methods courses are now handled.

¹ *School and Society*, May 1, 1915, p. 621; also *American Mathematical Monthly*, April, 1915, p. 119.

² *Thirteenth Yearbook of the National Society for the Study of Education*, Part I.

³ Parker, *Methods of Teaching in High Schools*, p. 60.

Another severe criticism that is often heard is that there is a great deal of duplication of subject-matter in the so-called methods courses. One student said that he had taken three different methods courses and had received a certain amount of instruction that was practically the same in all. Such courses should be reorganized or the student should have his course arranged so that such duplication would be impossible. The solution no doubt involves the "getting together" of the group of people giving the methods courses. Certain standards and programs should be set up that will not permit of so much repetition and accompanying waste.

Four ways have been offered by means of which prospective teachers may profitably proceed:¹

1. By reading the published results of the experience of others. In connection with this method of improvement it ought to be said that such works as Young's *The Teaching of Mathematics*, Smith's *The Teaching of Elementary Mathematics* and *The Teaching of Geometry*, Schultze's *The Teaching of Mathematics in Secondary School*, and Evans' *The Teaching of High-School Mathematics* have been prolific sources of information and help to a large number of prospective teachers.

2. By personal consultation with experienced teachers. This is always a helpful method of improvement if the experienced teacher is a good teacher.

3. By observing teachers at work. In the report of Committee No. 8 of the International Commission on the Teaching of Mathematics (p. 30) we find this statement: "It is believed by many that the best pedagogical training comes through careful and diligent study of the subject-matter under the guidance of an inspiring teacher who knows how to exhibit good methods and to impress them by example, rather than precept, upon the students." There is much in this statement provided the methods teacher is qualified to do a high type of teaching.

4. By actual teaching. It is said by some that actual teaching, even if it amounts purely to the trial-and-error method, is the best methods course in mathematics.

¹ Adapted from Young, *The Teaching of Mathematics*, p. 8.

Whatever else be included, it seems clear to the writer that all of the four methods above should have a part in any special-methods course.

We have referred in the first part of this paper to the situation twenty years ago in our own country with reference to the training of secondary teachers in mathematics and we have mentioned several points concerning the present situation. A little study of the development of the situation may add to a better understanding of the whole question of training teachers.

According to the report of the American Commissioners of the International Commission on the Teaching of Mathematics,¹ there were at least five different schools twenty years ago which established courses on the teaching of algebra and geometry which, together with a course on general pedagogy, formed a certain professional training for high-school teaching in mathematics. Up to 1900 only four other colleges were known by this committee to have added to their programs courses on the pedagogy of mathematics. From 1900 to 1910 about twenty-five other colleges besides those referred to above developed courses such as "The History and Pedagogy of Secondary Mathematics," "The Teaching of Mathematics in Secondary Schools," and "Teachers' Course in Algebra and Geometry." "For the other high-school studies, such as Latin, English, German, physics, and chemistry, there has been a corresponding development of professional courses on the teaching of these subjects."

In 1911 there were at least twelve schools of education in this country with provisions for professional training, and since that time others have been organized.

There are at the present time a few normal colleges, separate from any university or college, where the work in the training of teachers is of as high grade as that of the colleges and leads ultimately to the Bachelor's degree.

The difference between the work offered by these schools of education and normal colleges and that offered by a university department is that professional courses of study are found to be broader in scope and more technical, i.e., the courses in the latter

¹ *Bulletin No. 12, 1911.*

often include directed observation and supervised practice teaching in some high school.

In each of the schools reported on by the American Commissioners

the minimum training of a professional nature for secondary work is a definitely organized course on the teaching of secondary mathematics. . . . This course varies in length from 17 to 90 hours of class work, the average for all of the institutions being 48 hours. The methods of handling the course is, in general, by lectures, recitations on assigned readings, discussions, written reports, and quizzes. The subject-matter of this course varies somewhat in each institution though certain topics are common to practically all of the courses.

The committee prepared a composite syllabus of a tentative maximum course based on the syllabi sent in by the leading institutions.

The course treats of such topics as the reasons for teaching algebra and geometry, the historical development of these subjects and of the methods of presenting them, the world's best literature concerning the teaching of mathematics, the mathematical curriculum in American and foreign secondary schools, the adaptation of a curriculum to the needs of various types of schools, a study of typical American and foreign texts for secondary schools, and the various movements to reform the teaching of secondary mathematics at home and abroad. Some attention is often given to the methods of conducting a recitation in mathematics with discussions of the hueristic method, the laboratory method, the no-text method, etc. The course also contains a review of typical parts of algebra and geometry offering scientific or pedagogic difficulties, such as the number system of algebra, equivalent equations, factoring, theory of exponents, simultaneous quadratic equations, graphic solutions, the foundations of geometry, the sequence of propositions, the treatment of parallels, loci, limits, incommensurable cases, methods of attacking exercises in geometry, and the nature of the problems and exercises of algebra and geometry. The reading of current periodical literature on the teaching of mathematics and the discussion of such topics as teaching algebra and geometry together, the fusion of plane and solid geometry, etc., are often included.

Such books as Smith's *The Teaching of Elementary Mathematics* and *The Teaching of Geometry*, and Young's *The Teaching of Mathematics* are frequently used as outlines or texts for such a course. Fine's *College Algebra and Number System of Algebra*, Chrystal's *Algebra*, and the histories of mathematics by Ball, Fink, Cajori, Gow, and Allman are frequently reported as reference books.

The prerequisites for the above course are one year of college mathematics in about half of the cases and through the calculus in the others. Even where

the former requirement exists, it usually happens that most of the students have had the calculus and such courses as the theory of equations and projective geometry as a minimum preparation before entering the pedagogical course. This pedagogical course is normally taken in the Senior year.

In a few of the schools offering the teachers' courses, systematic work in observation and practice teaching was given in connection with the methods work several years ago. This work was carried on either in a high school connected with the school of education or by a special arrangement in the public city high schools.

At the present time the College of Education of the University of Minnesota does both. The University High School is not large enough to accommodate all of the students who want to observe and teach; so an arrangement has been made with Superintendent Spaulding of the Minneapolis city schools whereby prospective teachers may do observation and practice teaching in the public high schools.

In order to find out what is being done in this country at the present time in special-methods courses in the teaching of mathematics, the writer made a survey of several of the leading schools of this country. These schools were asked to report on what they were doing in their special-methods courses in mathematics and to contribute any further ideas they might have as to what they thought ought to constitute such a course.

It was not possible to secure replies to all the inquiries sent out, but from those received the writer has collected a few interesting facts.

1. One school has three different teachers' courses: one for those without experience, one for graduate students who have had experience, and one for teachers of applied mathematics.

2. In nearly all of the methods courses such texts as Young's *The Teaching of Mathematics* and Smith's *The Teaching of Elementary Mathematics* are used as references.

3. Some offer no special-methods courses at all.

4. The average time given is from two to three hours per week per semester.

5. Very few have directed observation in connection with the methods courses in mathematics.

6. Only one or two schools out of those reporting require any teaching in connection with the methods course in mathematics.

7. In a few cases at least two methods courses are required.

8. In several schools a great deal of the time is given over to a discussion of historical material and subject-matter with a minimum of reference to technique in teaching and the real live problems of the classroom.

The study which the writer has made has not been complete enough to include all the important facts that may exist in regard to special-methods courses, but from the replies sent in it is clear that not enough emphasis seems to be given in many of these courses to directed observation of high-school work and to technique of teaching.

As a result of all this study of special-methods courses, together with his own experience in the classroom and personal consultation with many high-school teachers and practice students who have taken courses in special methods in mathematics, the writer wishes to submit some suggestions in regard to tentative special-methods courses in mathematics in the hope that in the near future the adoption of standards and further study may give us a type of training that will meet the demands of the time.

I. Special-methods courses should be organized so as to give more time (at least some time) to directed observation and teaching by the trial-and-error method. This will be possible only where high-school classes are accessible.

II. The student teacher's course should be so clearly outlined and the prerequisites¹ so set up that a great deal of the material now given in special-methods courses may give way to the directed observation and practice teaching referred to above. There is no reason why the training for teaching may not be made as efficient and definite as for law, medicine, or engineering.

III. The person giving the methods course should, if possible, be in actual contact with the classroom while the observation or practice teaching is being done by his student teachers. He may be the head of the mathematics department in the high school, the

¹ See *Bulletin No. 14*, 1912, U.S. Bureau of Education, on "Proposed Minimum Requirement."

head of the mathematics department in the college of education, or he may be a member of the college or university department of mathematics, but in any case he ought to see what is going on at the time his methods class sees it. He may actually teach the class himself or he may take the class to observe the work of some good high-school teacher. If the high-school teacher is a good one, it is perhaps better for the methods teacher to look on with his student teachers. In this way he gets a fuller and more spontaneous reaction from these students in subsequent discussions of the classroom situation.

IV. These discussions of the classroom situation ought to afford the most excellent opportunities for instruction in technique. The classroom will thus be serving the student teacher in much the same way as the clinic and hospital experience as interne serve the prospective physician.

V. If any students are asked to teach, those working first should be carefully selected from the stronger members of the class and if possible from those who may have had a little experience. In no case should a student who is not entirely capable be given absolute control of a class. This of course must be left to the judgment of the person giving the methods course. If necessary, the student should be helped in making his plan when he first begins to teach and should be judged by the way in which he uses it.

VI. Students should be required to do some observing¹ in classes other than in the class and in the subject which they expect to teach so as to make some comparisons of the recitations visited in regard to such items as:

A. Teachers:

1. Personality and preparation of teachers
2. Routine factors of recitation
3. Devices
4. Discipline
5. Assignment

B. Pupils:

1. Interest in and attitude toward subject
2. Quality of oral and written work
3. Deportment

¹ See "Suggestive Outlines for Observation" on p. 5 of the *Report and Recommendations of the Joint Committee on Practice Teaching*, published by the University of Minnesota.

VII. A few of the first meetings of the class in special methods may have to be devoted to a discussion of methods of taking notes on the classroom situation which the student teachers are to observe or they may not receive a maximum of profit from their visitations. The amount of time spent on such discussions will vary with the school. The "Record of Teaching Efficiency" prepared by the College of Education of the University of Chicago will furnish special-methods teachers with many ideas as to what things may be looked for in visits to the classroom.

The following directions to students who are to do directed visiting may be helpful:

1. Try to reach the classroom which you are to visit a little before time for the recitation to begin. Introduce yourself if possible, and tell the teacher in charge why you are there. The average teacher does not care as a rule to have people coming into his classes after the recitation has begun. Stay if possible until the recitation is over. This is as important as getting there on time. Be courteous enough to pay the very best attention to all that takes place while you are in the room.

2. Remember that real criticism is constructive as well as adverse. Nobody ever gets the most from his visiting who is always looking for a chance to give the teacher a "black eye." The truth is perhaps that there are more chances to compliment devices and to gain inspiration than we think.

3. Do not become so engrossed in the work as to forget to jot down significant points, and by all means give information that is definite and to the point concerning the recitation. Be sure you have something from the recitation in "black and white" to substantiate what you may say concerning it. Do not be afraid to be detailed in your statements. Such comments as "The teacher's methods were efficient," "The way he handled a slow pupil was interesting," are absolutely worthless as intelligent comments on any recitation. Describe in detail some of the methods used and the subsequent reactions, show how the slow pupil was dealt with, and present the situation from beginning to end. Only in this way can we successfully handle individual differences.

4. What attitude have the pupils toward the work? Is there a spirit of co-operation between the teacher and the pupils?

How do the pupils respond to the tasks set for them by the teacher?

5. Is the teacher giving the pupil any good habits of study? Is there any reference to independent work outside of class? Is there any provision made for instructing the slow pupils outside of the recitation?

6. Note the routine factors of the situation such as lighting, ventilation, seating arrangement, material equipment for the subject to be taught, etc.

7. Study the recitation as a whole. Does the teacher ask good questions? Write down significant ones. Do the pupils show great interest by volunteering or do they respond only when called upon by the teacher? Does the teacher use sarcasm? Are there any questions of discipline at all? How does the teacher handle them? What would you do if you were in charge? Is the recitation of such a nature that new problems arise in class? Does the teacher equip the pupils for the handling of these problems?

8. Do not form any final opinion of a teacher upon the basis of the visits of a day or even of a week. A fair judgment will involve careful visiting over a longer period of time.

9. Keep your notes carefully and neatly and do not destroy them. They will probably be of use to you later when you go out to teach.

VIII. In addition to the discussions regarding what is seen from time to time in the classroom, it ought to be possible to work in discussions of certain questions which are of importance to the beginning teacher.

1. The student teacher should be prepared to answer three important questions relating to the subject of mathematics: why it is taught, what is taught, and how it is taught. The answer to the first question involves a study of the purpose and value of the study of mathematics. The teacher must know all he can about the why of the teaching, not only that he may be able to inform others of the purpose and value of teaching mathematics, but also because he needs to keep the place and function of mathematics in the curriculum clear in his own mind. In no other way can we

secure the best teaching.¹ The answer to the second question is determined largely by the makers of courses of study and by those who are responsible for the selection of textbooks. However, the teacher is always free to let his own independent notions guide him largely in this matter; therefore some attention certainly should be paid in a special-methods course in training prospective teachers to a review of courses of study and texts in a constructive way. However, the study of the subject itself is the important thing. A well-trained teacher should be able to get along without a text if necessary. It might be well at this point to consider also how the nature and content of courses of study may be modified by such items as the character of the community in the midst of which the high school must function, the length of the prescribed course, the relation of mathematics to the other courses in a particular school, and the available equipment for carrying on such a course. The answer to the third question, how it is taught, involves a study of methods and modes. The classroom ought to furnish abundant opportunities for a discussion of this question since it is not likely that in any classroom one method will be used exclusively. For an excellent treatment of "methods and modes" the reader is referred to chap. iii in Young's *The Teaching of Mathematics*.

2. As suggested above, the student should be helped in making his plan if necessary when he first begins to teach and should be judged by the way in which he uses it. Later the question of lesson plans² ought to be discussed fully with regard to their purpose, guiding principles underlying their construction, types to be considered; and, finally, the actual writing of such plans should be required of all, for whether the student teaches in the practice school or not, we are preparing him no doubt for a larger school of practice where it is of equal if not greater importance that he know just exactly what he wants to accomplish during the recitation.

3. Then it is of some importance that the recitation itself be considered with reference to (a) its traditional function and (b) present-day views.

¹ See Young, *The Teaching of Mathematics*, chap. ii.

² See McMurry, *The Method of the Recitation*, p. 329.

4. Some attention should be paid to a study of the psychology¹ of the subject as illustrated by the following suggestive studies:

- A. A study of the arrangement of material in certain texts to see if the order is psychological.
- B. A study of the problem of individual differences with regard to the following items:
 - 1. Proof of the existence of the problem
 - 2. Normal probability curve
 - 3. The need for supervision
 - 4. Value of study classes—teaching children how to study²
 - 5. Consideration of slow and fast workers³
 - 6. Methods
 - 7. Reference material
- C. A study of present standards and measurements of mental ability in regard to
 - 1. Significance of movement
 - 2. Historical and classroom study of tests in arithmetic and algebra such as the Courtis, Monroe, and Thorndyke tests
 - 3. Grading of test papers in mathematics with and without standards⁴
 Here it seems to the writer is the place to raise the following questions with the teacher students:
 - a) Importance of deciding what points other different questions are to test
 - b) What weights shall be given to the correct answers of these questions
 - c) Whether pupils should know at the outset the relative importance of parts
 - d) Necessity of teaching children to pick out the problems they are sure they can do first so as to use more efficiently the time allotted for the test
 - e) Departmental methods of grading final examinations

Then there are several other items of interest and importance which may be taken up and discussed in a special-methods course:

- 1. A list of reference books suitable for the high-school pupils and for the teachers should be made.⁵ There are certain works

¹ In this connection Judd's *Psychology of High School Subjects* is very helpful.

² See McMurry, *How to Study*.

³ The reader is referred to articles by Schorling in the *School Review*, October and December, 1915, on "The Problem of Individual Differences in the Teaching of Secondary-School Mathematics."

⁴ In this connection Professor Cajori's article in the *Proceedings of the Central Association of Science and Mathematics Teachers* for 1913 is very interesting.

⁵ See the suggestive list at the end of this paper.

which the high-school pupils can appreciate, such as Ball's *Primer of the History of Mathematics* and *Mathematical Recreations and Problems*. The teacher should be put in touch with certain books on special method, such as Young's *Teaching of Mathematics*, should be informed about the bulletins issued by the Department of Education at Washington, and should become familiar with standard sources of mathematical information.

2. The discussion of what should constitute a minimum of equipment and a means of obtaining the same should be discussed and some concrete conclusions reached.

3. The value of an exhibit of the work of the pupils in mathematics.

4. The place and value of mathematical clubs in the school.

5. The value of mathematical contests between classes or schools carried on in much the same fashion as a contest in public speaking.

Every student in the methods course should be required to prepare a term paper on a subject that has as concrete and valuable a setting as possible. For example, one of the students in the special-methods course at the University of Minnesota is visiting every day a third-year class which is taking unified mathematics, and for his term paper he is going to give his opinion as to the advisability of unifying the algebra and trigonometry in the third year.

At the close of the semester surely some written test should be required of all students. This test should be of such a nature that from the results the instructor may be able to find out those who have really grasped the significant features of the course and give the proper justice where credit is due.

A great deal of what has been said for the special-methods course in mathematics applies equally well to the special-methods courses in the other subjects. In any event it is the hope of the writer that whatever may have been said here will not be considered as final but only as tentative suggestions for your thoughtful consideration.

A LIST OF REFERENCE BOOKS AND MAGAZINES FOR TEACHERS OF MATHEMATICS IN HIGH SCHOOLS

I. Books of a general pedagogical nature:

1. Parker, *Methods of Teaching in High Schools*. Ginn & Co.
2. Judd, *The Psychology of High School Subjects*. Ginn & Co.

These two books are the best of their kind available and are extremely interesting and helpful. Every teacher of high-school mathematics should read them.

II. Books on the teaching of mathematics:

1. Young, *The Teaching of Mathematics*. Longmans, Green, & Co.
2. Young, *The Teaching of Mathematics in Prussia*. Longmans, Green, & Co.
3. Smith, *The Teaching of Elementary Mathematics*. Macmillan.
4. Smith, *The Teaching of Geometry*. Ginn & Co.
5. Schultze, *The Teaching of Mathematics in Secondary Schools*. Macmillan.
6. Safford, *Mathematics Teaching*. D. C. Heath & Co.
7. Evans, *The Teaching of High School Mathematics*. Houghton Mifflin Co.
8. Nunn, *The Teaching of Algebra (Including Trigonometry)*. Longmans, Green, & Co.
9. Branford, *A Study of Mathematical Education*. Clarendon Press.
10. Carson, *The Teaching of Geometry*. Longmans, Green, & Co.
11. Carson, *Mathematical Education*. Ginn & Co.

A familiarity with all of the books listed above is sure to increase the interest and efficiency of any high-school teacher of mathematics.

III. Books relating to mathematical topics, intended to improve the teaching of mathematics:

1. Young, *Fundamental Concepts of Algebra and Geometry*. Macmillan.
2. Young, *Monographs on Topics of Elementary Mathematics Relevant to the Elementary Field*. Longmans, Green, & Co.
3. Manning, *Non-Euclidean Geometry*. Ginn & Co.
4. Manning, *Fourth Dimension*. Munn & Co.
5. Hilbert, *The Foundations of Geometry*. Open Court Publishing Co.
6. Klein, *Famous Problems in Elementary Geometry*. Ginn & Co.
7. Conant, *The Number Concept*. Macmillan.
8. Fine, *The Number System of Algebra*. D. C. Heath & Co.
9. Heath, *The Thirteen Books of Euclid*. Cambridge University Press.
10. DeMorgan, *Study and Difficulties of Mathematics*. Open Court Publishing Co.
11. Lagrange, *Lectures on Elementary Mathematics*. Open Court Publishing Co.

12. Poincaré, *Science and Hypothesis*. Science Press.
13. Russell, *Essay on the Foundations of Geometry*. Cambridge University Press.
14. Chrystal, *Algebra*, 2 vols. A. & C. Black.
15. Manning, *Irrational Numbers*. Wiley & Sons.

IV. Books containing recreational material:

1. Ball, *Mathematical Recreations and Problems*. Macmillan.
2. White, *A Scrap-Book of Elementary Mathematics*. Open Court Publishing Co.
3. Jones, *Mathematical Wrinkles*. S. I. Jones, Gunter, Tex.
4. Sykes, *Source Book for Geometry*. Allyn & Bacon.
5. Schubert, *Mathematical Essays*. Open Court Publishing Co.
6. Abbott, *Flatland*. Little, Brown & Co.
7. Manning, *Fourth Dimension*. Munn & Co.
8. DeMorgan, *Budget of Paradoxes*. Open Court Publishing Co.
9. Leacock, *Literary Lapses*. John Lane, New York.
10. Cheever, *The King of Calculators*. E. J. Cheever, Little Rock, Ark.

V. Books of historical nature:

1. Ball, *A Short History of Mathematics*. Macmillan.
2. Ball, *A Primer of the History of Mathematics*. Macmillan.
3. Cajori, *A History of Mathematics*. Macmillan.
4. Fink, *A Brief History of Mathematics*. Open Court Publishing Co.
5. Gow, *History of Mathematics*. Cambridge University Press.
6. Allman, *Greek Geometry from Thales to Euclid*. Longmans, Green, & Co.
7. Stamper, *A History of the Teaching of Elementary Geometry*. Teachers College, Columbia University.
8. Jacobs, *The Seven-Tellers*. Hermann von Jacobs, Berlin, Germany.

VI. Books available as texts:

1. A representative selection from all the standard older texts and the modern texts on high-school mathematics should be in the teacher's library and he should be able to choose from this list texts that would suit his purpose.

VII. Magazines:

1. Of a mathematical nature:
 - a) *The Mathematics Teachers*. The Mathematics Teacher, Syracuse, N.Y.

This is the only journal dealing entirely with mathematics in the secondary school. It contains many helpful articles for mathematics teachers.

- b) *The American Mathematical Monthly*. B. F. Finkel, Treasurer, Springfield, Mo.

This magazine deals chiefly with mathematics foreign to the secondary-school field, but it is a very good thing for the high-school teacher to make it the means of helping him on to higher knowledge.

- c) *School Science and Mathematics*. Mount Morris, Ill.

Though not of a strictly mathematical nature, this magazine contains some very stimulating articles for high-school teachers of mathematics and keeps them in closer touch with the allied sciences.

- d) Two good technical magazines, e.g., *Scientific American* and the *Scientific American Supplement*.

2. Of a general nature:

- a) *School Review*. University of Chicago Press, Chicago, Ill.
- b) *School and Society*. Science Press, Harrison, N.Y.

These two magazines are two of the most stimulating and helpful sources of information for high-school teachers.